NORMAL AND ABNORMAL PERMEABILITY

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Some investigations by the writer on the permeability of protoplasm have recently been reviewed by Höber.[1] It seems evident that his views depend in part on a misunderstanding in regard to the relative amount of permeability under normal and abnormal conditions, and in part on a misunderstanding of the author's meaning.

The investigations of the writer show that the permeability of cells of Laminaria can be determined by measuring their electrical resistance. In sea water the normal permeability remains unaltered for a long time: in a solution of NaCl of the same conductivity as the sea water the permeability rapidly increases (as shown by the lessened resistance): this increase continues until the tissue is dead. The alkali salts behave in general like NaCl. The addition of a definite amount of $CaCl_2$ to the NaCl prevents (at least for some time) the increase of permeability which would occur in pure NaCl.

On this Höber comments as follows: "Osterhout schliesst aus diesen Versuchen, dass der lebende Protoplast von den Ionen der Alkalisalze leicht zu durchdringen ist. Aber ich halte diese Folgerung auch hier wieder für nicht richtig. Vielmehr zeigen die Versuche nur, dass die Laminariazellen ein Widerstandsmaximum aufweisen, wenn sie sich unter den physiologischten Bedingungen des Aufenthalts in Meerwasser befinden, und dass sie den Übergang in abnorme Bedingungen mit Widerstandssenkung, also mit Permeabilitätsverringerung[2] beantworten, vergleichbar der, die auch den Tod begleitet."

As has been suggested, Höber's views are due, in part at least, to a misunderstanding and it seems desirable to indicate briefly wherein this lies.

The writer has laid emphasis on the rapid penetration of pure NaCl and similar salts because this penetration was expressly denied by Overton and was used by him as one of the chief evidences for the lipoid theory of permeability. As is well known Overton reported that cells of Spirogyra when plasmolyzed in NaCl did not recover, thus showing that the salt did not penetrate. The writer repeated this experiment and found that penetration occurred: this conclusion was

[1] Die physikalische Chemie der Zelle und der Gewebe. 4te Aufl. 1914, S. 362 ff.

[2] "Permeabilitätssteigerung" is evidently meant.

confirmed by measurements of electrical conductivity. The writer laid emphasis on these facts in order to call attention to the misleading character of Overton's conclusions and to indicate that the lipoid theory does not rest on a firm foundation.

The writer, however, has nowhere stated, as Höber seems to think, that the penetration in pure NaCl represents the normal state of things. He has, on the contrary, emphasized the fact that in sea water (and in other solutions in which life can be maintained for a long time) the permeability is much less than in pure NaCl because $CaCl_2$ (and other salts) are present to antagonize the action of NaCl.

On the other hand the permeability in sea water (which the writer regards as the normal permeability of Laminaria), while less than that in NaCl, is by no means the minimum permeability, nor is the resistance in sea water the maximum resistance, as Höber seems to suppose. The net resistance of a cylinder of tissue, which in sea water is 800 ohms, may rise to over 1,600 ohms in a solution of $La_2(NO_3)_6$ which has the same conductivity as sea water. In other words the maximum resistance is at least twice as great, and the minimum permeability at least 50 per cent less than that found in sea water.

Under these circumstances we are not justified in speaking (as Höber does) of the "normal impermeability" of protoplasm to salts, unless it is understood that we mean by "impermeability" merely a rate of penetration considerably lower than that found in dead cells. In the present instance it was found that the resistance of the cylinder of dead tissue was about 100 ohms, which was approximately the same as that of a cylinder of sea water of the same size. We can not, however, conclude that the resistance of the living protoplasm (in sea water) is just eight times as great as that of dead cells, for in the living tissue a part of the current passes between the protoplasts, travelling in the intercellular substance in which protoplasmic masses are imbedded.

It is evident that much confusion will[1] disappear when such terms as permeability and impermeability can be quantitatively defined in all cases. The writer has sought to formulate quantitative expressions,[3] not only for permeability but also for such conceptions as injury and vitality. It is to be hoped that the study of permeability may before long be placed on a quantitative basis.

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[3] Cf. Science, N. S. 40: 488. 1914.